Comparison of Aspiration and Inhalation Exposure Methods for Predicting Pulmonary Toxicity of Biomass Smoke

Yong Ho Kim[1], Charly King[1], Q. Todd Krantz[1], Ingrid J. George[2], Marie M. Hargrove[3], John McGee[1], Lisa Copeland[1], Michael D. Hays[2], Matthew S. Landis[4], Mark Higuchi[1], Stephen H. Gavett[1], M. Ian Gilmour[1]

[1]NHEERL, [2]NRMRL, [3]ORISE, and [4]NERL, US EPA, Research Triangle Park, NC, USA

We have previously assessed lung toxicity of biomass smoke particulate matter (PM) from flaming versus smoldering phases of five different fuels (oak, peat, pine, pine needles, and eucalyptus) following a single aspiration exposure (100 μg of PM) in mice, and reported that the greatest lung toxicity was for eucalyptus smoke (from smoldering and flaming phases) or peat smoke (from flaming phase), while the least lung toxicity was for oak smoke (from smoldering and flaming phases). Since the aspiration exposure method is not a natural or physiologic exposure route however, our findings may not be readily transferable to real-world exposure situations. Thus we conducted inhalation exposures on a subset of the biomass smoke fuels (oak, peat, and eucalyptus) under smoldering and flaming conditions, and compared the results with the previous findings. Mice were exposed to the biomass smoke for 1 hour/day for 2 days and then assessed for lung toxicity at 4 and 24 h after the second exposure. PM levels were actively controlled to yield approximately 40 and 4 mg m^{-3} for the smoldering and flaming smoke, respectively. The resulting carbon monoxide (CO) levels ranged from approximately 60 to 110 ppm. Deposited PM mass in entire respiratory tract of mice was calculated to be approximately 75 and 7 μg of PM for the smoldering and flaming respectively (determined by multiple-path particle dosimetry (MPPD) model). The peat (flaming and smoldering) and eucalyptus (smoldering) smoke significantly induced lung toxicity (neutrophil influx) at 4 h and the toxic outcome was further increased at 24 h after exposure to the peat (flaming) smoke. No lung toxic responses were observed at any of the oak smoke exposure conditions. Compared with our previous findings, we found good correlation of the lung toxicity potencies (neutrophil influx per PM mass) between the inhalation and aspiration methods in mice exposed to the peat ($p < 0.001$) and eucalyptus ($p = 0.0056$) smoke, suggesting that the aspiration exposure method provides a comparable prediction of pulmonary toxicity from biomass smoke inhalation. Overall, our findings suggest that wildland fire smoke in the rich regions of peat and eucalyptus fuels may induce greater health effects than smoke from oak fires, and that on a mass basis, there is a greater health risk from flaming smoke compared to smoldering emissions. [This abstract does not represent EPA policy]